Energy/carbon rebound on a company level

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William Stanley Jevons

- His *The Coal Question* (1865) was the first study to express concern about what we now call **energy rebound**. He recognized major impacts of uptake of steam engines by **companies/industry** ("technology diffusion").
- As opposed, more recent research on rebound suggests a key role for **consumers/households**.
- But since rebound applies to all technologies, it is potentially **relevant to any type of consumer and business activity**
  - In fact, I see more similarities than differences

Definition of energy rebound

Potential energy savings of adopting an energy-efficient *technology or practice* are offset by subsequent *behavioral and systemic* responses that increase energy use, resulting in diminished net energy savings.

Source: Exadaktylos F., van den Bergh, J. (2021). Energy-related behaviour and rebound when rationality, self-interest and willpower are limited. *Nature Energy* 6(12): 1104-13.

4 fundamental reasons for energy rebound

1. Improved efficiency relieves *limits*: firm activities and energy use can grow then

2. Diffusion of more efficient *general purpose technologies* *(e.g., engines, batteries, light gear, transport vehicles; also new composites/materials that are energy-intensive in production)*

3. *Bounded rationality* of firm managers and employees: myopia, habits or partial goals – *despite good intentions*

   – A variety of behavioral theories of firms stress this as well: e.g., Nelson & Winter's "organisational routines".

4. Solutions often create more intra/extra-organizational complexity or material use (e.g., insulation) => somewhere energy use ↑

Energy-rebound pathways for firms

- **More intensive use** of efficient energy-consuming equipment
- **Purchase** of units that are larger or have more functions
- **Re-spending/re-investment** of financial savings due to conservation (or higher salaries => consumption ↑)
- New, more energy-efficient devices **embody energy** (production-chain/ lifecycle effects)
- Changes in the **factor input mix** => indirect energy use
- **Diffusion** of more (energy-)efficient technologies (in turn triggering R&D/innovation effects in the longer run)
- … and surely more, as discussed in **the report**.

Economic mechanisms essential

- Incomplete list:
  1. Income/spending effects
  2. Factor substitution
  3. Competitiveness changes (reduced cost/price, higher demand)
  4. Market interactions (incl. half-products)
  5. Financial and labor markets
  6. International trade and relocation
  7. Technological diffusion

  – Micro: 1,2,3,7. Meso: 3,4,5. Macro: 5,6.

- One can further identify various **feedback loops**, as studied by Santarius, T. (2016): Investigating meso-economic rebound effects. *J. Cl. Prod.* 134, 406-13.

- So many pathways, mechanisms & feedbacks **complicate empirical research** to assess magnitude of rebound. Add to this **limited time, space & system coverage** => rebound is easily **underestimated**.

Sector differences

- Rebound more likely with consumers than firms? – C focus on **spending** and F on **saving financial costs**.
- Rebound likely to differ btw sectors related to **energy/total cost ratio**, and **low-carbon choice/substitution options**.
- Rebound differs among **energy technologies**. Reviews indicate that it is low for lighting (up to 15%); high for space heating (up to 60%); and moderate for cooling (up to 26%) and other processes (up to 20%) in firms; moderate for aviation (19%); and high for fuel-efficiency improvements in motorized transport (up to 96%).
- Energy rebound depends on which **energy carriers/sources** dominate in sectors: Price/cost savings higher for oil, lower for coal – due to global vs regional markets. **Carbon rebound** further affected by carbon content.

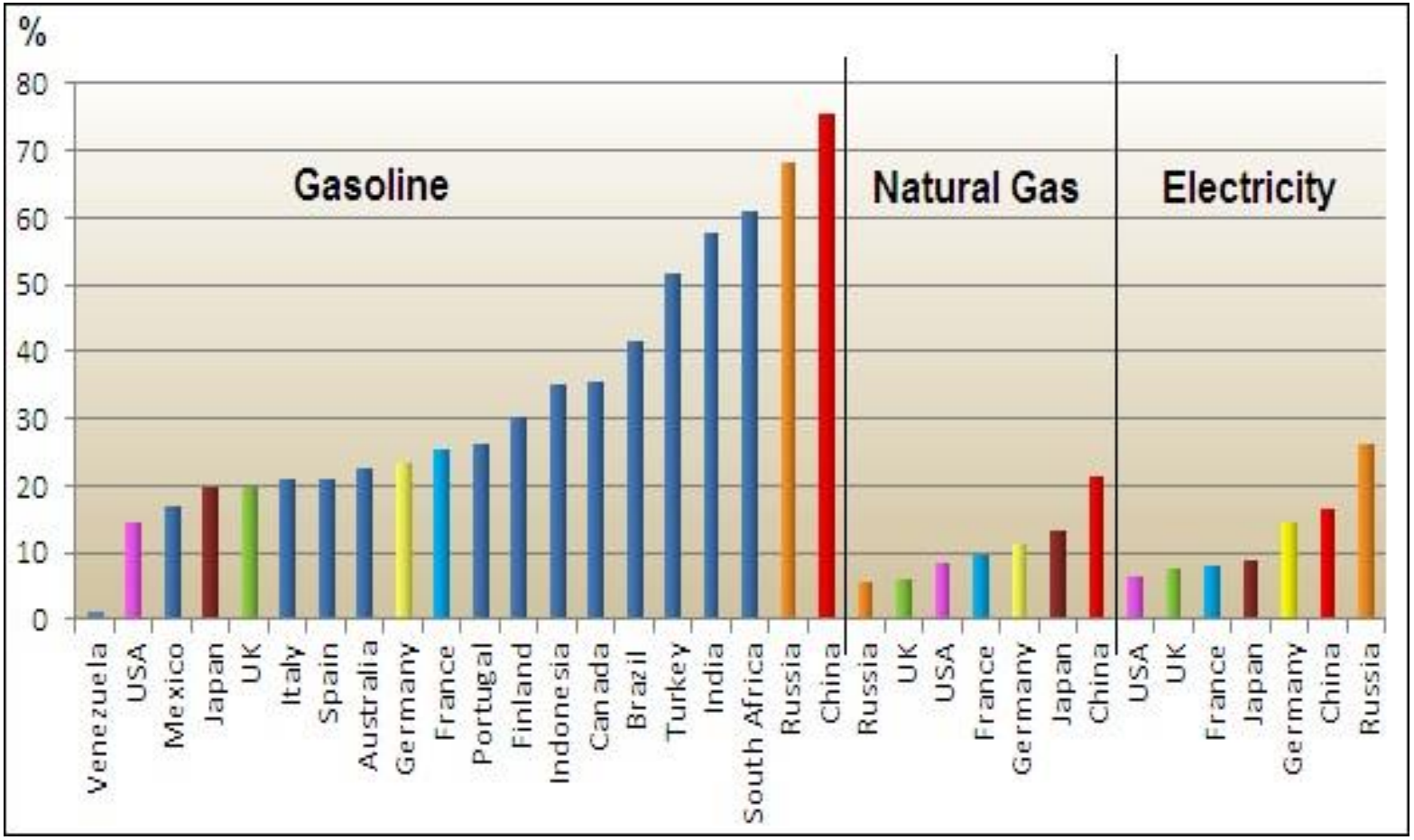
For references to support these claims see the appendix in: van den Bergh, J. (2017), Rebound policy in the Paris Agreement, *Climate Policy* 17(6): 801-813.

International differences

- **Neglected in the report?**
- *Rebound differs between countries:* due to industry structure, local (cheap) energy resources, dependence on international trade/transport, and development level.
- Studies indicate it is particularly high in emerging economies: many recent studies arrive at estimates >50% and some more than 100%.
- Two main reasons: cost of energy is relatively high (global oil prices), and agents far from saturated regarding energy services.
- Applies to both consumers and **companies**.

Rebound diversity among countries & energy carriers

Diversity due to prices, energy/fuel taxes & carbon intensity of economy



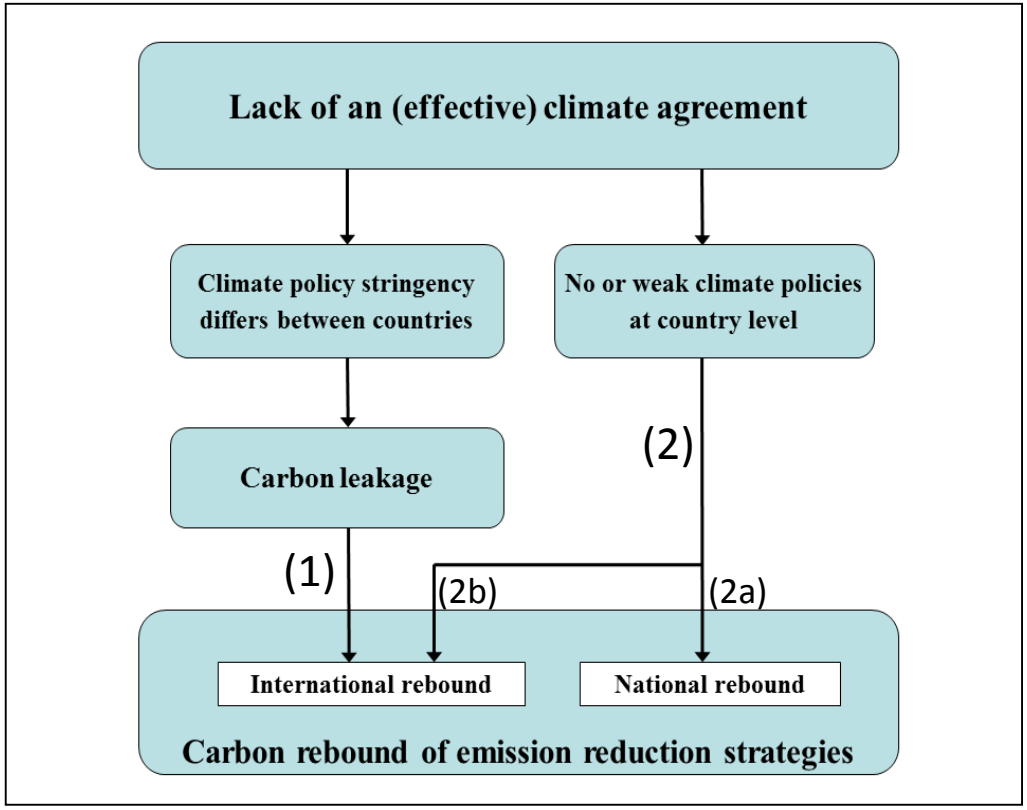
Source: Antal, M., van den Bergh, J. (2014). Re-spending rebound: A macro-level assessment for OECD countries and emerging economies. *Energy Policy* 68: 585-590.

"Rebound policy": further argument for carbon pricing

- **The report** is positive about a variety of instruments. But while they can stimulate energy conservation, I'm sceptical about their ability to limit rebound. E.g., **standards & esp. adoption subsidies reinforce rebound**.
- Moreover:
  - Impossible to reach all emissions with **standards**: millions of products/technologies.
  - **Targets** can be easily evaded. Individual targets arbitrary, inefficient and technically/politically troublesome *(Global target with price = ETS).*
- Most effective way to limit rebound is through systemic **carbon pricing**
  - **Undoes cost reduction** of energy efficiency driving rebound
  - **Reaches all decisions** and hence **controls complex feedbacks** underlying rebound.
  - ***Cap-and-trade* especially effective**: rebound tendency elicits higher carbon price
    (van den Bergh, 2011, Energy conservation more effective with rebound policy. *Env&Res. Econ.* 48)
    - Good implementation needed. **EU-ETS** high prices 2022, but only applies to large firms.

Beware: International rebound of national policy

Two channels: (1) **carbon leakage** (international trade & relocation effects) and (2) **rebound in other (esp. developing) countries**.
Relevant as diversity of pledges in Paris Agreement likely to trigger both.



Source: van den Bergh, J. (2017). Rebound policy in the Paris Agreement: instrument comparison and climate-club revenue offsets. *Climate Policy* 17: 801-813.

Challenges and research gaps

- Much of what happens in companies is **secret** – holds for technologies, costs, and energy use.
- Rebound in **small, medium & large firms** – differences?
- **Interaction sectors** – e.g., car mobility & electricity generation
- **Current high energy prices** affect rebound? Trigger energy conservation with less rebound; but too recent for empirical evidence.
- **Rebound and bounded rationality in/of firms**: purchasing vs operating costs, spillovers, defaults/habits, inattention; social influence
  - Possibly something to learn from the "energy efficiency gap" literature.